# AEROSPACE RECOMMENDED PRACTICE

| ARP1804™ | REV. B |
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Superseding ARP1804A

## Electric Baggage/Cargo Tractor

RATIONALE

Minor update to accommodate 24 VDC auxiliary electrical systems and integrated drive axles. References to specific paragraphs in related SAE documents were removed as they could change in revisions of those documents.

## 1. SCOPE

This SAE Aerospace Recommended Practice (ARP) outlines the design and performance requirements for a battery-powered electric tow tractor for the handling of baggage or cargo trailers in airline service. The use of “shall” in this document indicates a mandatory requirement. The use of “should” indicates a recommendation or that which is advised but not required.

## 2. APPLICABLE DOCUMENTS

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

### 2.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

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| AIR1316 | Airline Tow Tractor - Baggage/Cargo Factors for Design Consideration |
| AIR1375 | Minimum Safety Requirements for Special Purpose Airline Ground Support Equipment |
| AIR1898 | Maintenance of Batteries and Battery Charging and Servicing Facilities |
| ARP1247 | Aircraft Ground Support Equipment - General Requirements |
| ARP1328 | Aircraft Ground Support Equipment Vehicle - Wind Stability Determination |
| ARP1817 | Battery Industrial, Lead-Acid Type, for Use in Electric Powered Ground Support Equipment |
| ARP1892 | Electrical Connectors for Use in Battery Powered Ground Support Equipment |





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**SAE WEB ADDRESS:** **http://www.sae.org**

**For more information on this standard, visit**
https://www.sae.org/standards/content/ARP1804B/

AS4828 Technical Manual Requirements for Ground Support Equipment

SAE J163 Low Tension Wiring and Cable Terminals and Splice Clips

SAE J377 Vehicular Traffic Sound Signaling Devices (Horns)

SAE J551-1 Performance Levels and Methods of Measurement of Electromagnetic Compatibility of Vehicles, Boats (up to 15 m), and Machines (16.6 Hz to 18 GHz)

SAE J551-12 Vehicle Electromagnetic Immunity - On-Board Transmitter Simulation

SAE J561 Electrical Terminals - Eyelet and Spade Type

SAE J858 Electrical Terminals Blade Type

SAE J1127 Low Voltage Battery Cable

SAE J1128 Low Voltage Primary Cable

SAE J1654 Unshielded High Voltage Primary Cable

SAE J1673 High Voltage Automotive Wiring Assembly Design

SAE J1690 Flashers

SAE J1742 Connections for High Voltage On-Board Vehicle Electrical Wiring Harnesses - Test Methods and General Performance Requirements

2.2 ANSI Accredited Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ASME/ANSI B56.9 Safety Standard for Operator Controlled Industrial Tow Tractors

ANSI/NEMA No. 250 Enclosures for Electrical Equipment (1000 Volts Maximum)

2.3 CiA Publications

Available from CAN in Automation, AM Weichselgarten 26, DE-91058 Erlangen (Germany).

CiA Standard 418 CANOpen: Device Profile for Battery Modules

CiA Standard 419 CANOpen: Device Profile for Battery Charger

2.4 EN Publications

Available from CEN, Comité Européen de Normalisation, Avenue Marnix 17, B-1000 Brussels, Belgium, www.cen.eu or any European national standardization institutes, members of C.E.N.

EN12312-15 Aircraft Ground Support Equipment - Specific Requirements - Part 15: Baggage and Equipment Tractors (considered mandatory in the European Union in application of its Machinery Directive)

2.5 IATA Publications

Available from International Air Transport Association, Publications Assistant, 800 Place Victoria, P.O. Box 113, Montreal, Quebec H4Z 1M1, Canada, Tel: 1-514-874-0202, www.iata.org.

AHM 916 Basic Requirements for Ground Support Equipment Towing Interface

AHM 968 Functional Specification for Ramp Equipment Tractors

2.6 National Fire Protection Agency Publications

Available from NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org.

NFPA No. 505 Standard for Use, Maintenance and Operation of Industrial Trucks. Fire Safety for Powered Industrial Trucks

2.7 UL Publications

Available from UL, 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com.

UL 583 Electric-Battery-Powered Industrial Trucks

2.8 U.S. Government

Copies of these documents are available online at http://quicksearch.dla.mil.

MIL-STD-461E Electromagnetic Interference Characteristic Requirements for Equipment

3. DESIGN REQUIREMENTS

3.1 The tractor shall comply with all performance requirements over the full range of environmental factors specified in ARP1247.

3.2 The tractor shall comply with the requirements of ARP1328.

3.3 Electrical System

The electrical system shall consist of an appropriate size and type of traction battery pack powering a compatible electric motor(s) through an electronic controller(s) to produce smooth acceleration and operation. Traction battery voltage should reflect the best design for duty cycle, vehicle speed, tractive effort and minimum current losses. The traction battery charger shall be appropriately selected to properly charge the traction battery and meet the requirements of the particular application.

3.3.1 Traction Battery

3.3.1.1 The traction battery should comply with the requirements of ARP1817. A single battery should be provided of size and capacity to satisfy performance and accessory requirements. Operational characteristics should also be considered when selecting the proper battery, such as the average amp-hour draw, any non-gassing requirements, available maintenance personnel and facilities. The vehicle manufacturer shall provide the battery manufacturer's specifications, including the 1-hour and 3-hour discharge rating of the traction battery (in ampere-hours), and shall specify the operating time (in hours) which the battery will support, assuming the vehicle is operating continuously at 6.2 mph (10 kph) with a 14-ton dolly.

3.3.1.2 Means of restraining the traction battery in the lateral and longitudinal directions shall be provided.

3.3.1.3 Vehicle manufacturer should supply battery manufacturers recommended traction battery charging algorithm.

3.3.1.4 Vehicle manufacturer should supply traction battery maintenance requirements.

3.3.1.5 Vehicle manufacturer shall indicate the depth of discharge below which the traction battery should not be discharged.

3.3.1.6 The traction battery shall be protected by a cover, which can support one load of 250 pounds, applied to any 1 $ft^2$ (10.5 kg to any 1 $m^2$) of the cover.

3.3.1.7 The traction battery and traction battery compartment shall be designed such that electrolyte from the battery is captured in an auxiliary tray or the battery tray and not allowed to drain onto the ground, corrode parts of the tractor, create acid paths for current to flow to the chassis.

3.3.1.8 Battery cable connectors shall be located such that they create no danger of igniting gases expelled during battery charging. The location should also be convenient for charging while not subject to damage during battery removal or installation.

3.3.1.9 Manufacturer shall supply an MSDS for the battery and any materials used in the tractor that would not typically be found in an automotive shop.

3.3.2 Propulsion System

3.3.2.1 The electronic controller(s) and motor(s) shall be sized for the application and shall limit maximum battery discharge as specified in 3.3.1.5 to prevent degradation of battery life and abrupt loss of tractor operability. Such limit shall be adjustable, repeatable, and accurate within 10% battery state of charge.

3.3.2.2 All wiring and components used in the high voltage propulsion system shall be of a “two-wire” design (battery negative above chassis ground) and sized in compliance with SAE J1673.

3.3.2.3 Vehicles shall not contain exposed conductors, terminals, contact blocks or devices of any type that create the potential for personnel to be exposed to greater than 60 V (nominal battery voltage) (the distinction between low voltage and high voltage, as specified in SAE J1127). Access to any high voltage components shall require the removal of at least one bolt, screw, cover, or latch. Devices considered to be high voltage components shall be clearly marked as HIGH VOLTAGE. These markings should be installed at any point the voltage can be accessed by the end user. Additionally, cable and wire marking shall consist of orange wire and/or orange sleeves as required by SAE J1127.

3.3.2.4 All HIGH VOLTAGE (>60 V) cable shall comply with the requirements of SAE J1654. All low voltage cable shall comply with the requirements of SAE J1127 or SAE J1128 as applicable.

3.3.2.5 HIGH VOLTAGE (>60 V) connectors should utilize locking devices, shall be keyed to prevent mis-connection and should be moisture proof. HIGH VOLTAGE (>60 V) connectors should comply with the requirements of SAE J1742.

3.3.2.6 The tractor may utilize a single speed or multi-speed automatic or a continuously variable transmission. An alternative design may incorporate an integrated axle such as used in material handling equipment.

3.3.2.7 A propulsion power system operating at greater than 60 V shall be considered HIGH VOLTAGE and shall be isolated from the vehicle chassis such that leakage current does not exceed 20 mA with the battery connected.

3.3.2.8 An arrangement for the controller to increase braking by changing motor field current (called “plugging” or “regenerative braking”) shall be offered. Maximum regenerative braking settings shall be adjustable such that maximum current returning to the traction battery pack can be set to avoid potential damage to traction battery pack or electrical components.

3.3.2.9 If a DC traction motor is used, the motor should be accessible for brush inspection without having to remove the battery.

3.3.3 Accessory Power System

3.3.3.1 A 12 or 24 VDC accessory power system shall be used to power the following:

a. Two head lights on front of tractor (one each side).

b. Two tail lights on rear of tractor (one each side).

c. Two brake lights on rear of tractor (one each side).

A combination assembly may be used to accommodate the brake and tail lights. A horn shall be supplied and should comply with the requirements of SAE J377.

3.3.3.2 The 12 or 24 V system should incorporate a 2-wire system for isolation purposes. If chassis ground is used for the 12 or 24 V negative it shall be isolated from the traction system by at least 500000 Ω resistance. The 12 or 24 V system shall be powered from the main traction battery by an electronic DC-to-DC converter.

3.3.3.3 Low voltage connectors should comply with the applicable requirements of SAE J163, SAE J561, and SAE J858.

3.3.3.4 Low voltage wire shall meet the requirements of SAE J1128.

3.3.3.5 All electronic components shall be protected by an enclosure meeting the requirements of ANSI/NEMA 250-1997, Type 4 Enclosure.

3.3.3.6 The electrical/electronic systems shall incorporate proper shielding and filtering to assure electromagnetic compatibility with any and all communication and navigation frequencies in and around the airport ramp areas in accordance with MIL-STD-461. The tractor shall not be susceptible to externally generated electromagnetic fields and shall comply with the applicable sections of SAE J551-1. Additionally, vehicles shall not be susceptible to electric magnetic fields from an on-board radio transmitter and shall comply with the requirements of SAE J551-12.

3.3.4 Battery Charging

3.3.4.1 Interlocks shall be provided to prevent driving the tractor away when the tractor is connected to the charger.

3.3.4.2 Charging circuits shall be isolated from the vehicle chassis such that ground current from the grounded chassis does not exceed 20 mA at any time the vehicle is connected to an off-board charger.

3.3.4.3 Charge connector shall be prevented from being inadvertently connected to the controller or motor rather than the battery.

3.3.5 Electrical systems shall comply with the requirements of ARP1247.

3.4 Mechanical Systems

3.4.1 The tractor shall be a four wheel, rear wheel drive vehicle, with front wheel steer from the conventional left driver's seat position and a right passenger seat position. Excessive steering effort shall not be required to maneuver the tractor in tight quarters.

3.4.2 Tires shall be heavy duty pneumatic or equivalent and selected for rated loads and speeds. Single piece rims should be provided.

3.4.3 Service brakes shall be of a dual system hydraulic design with split master cylinder and indicator light on dash to warn the operator if one system fails.

3.4.4 The unit shall be equipped with an adjustable manual type hand brake with a pulling motion toward the operator engaging the brake. (See Section 8 for optional electric parking brake.) The directional control switch shall have three positions: forward, neutral and reverse. These positions shall be clearly indicated. Operation shall be located to the right of the steering wheel.

3.4.5 Under full rated load the minimum approach angle shall be 30°, the ramp breakover angle shall be 15° and the departure angle 25° for the standard tractors. For the low profile tractor, these angles are reduced to 15° for approach, 10° for breakover, and 20° for departure.

3.4.6 No portion of the tractor shall contact the ground with any combination of flat tires (refer to ARP1247).

3.4.7 The suspension system shall be adequate to prevent chassis bottoming under normal operating conditions with a full rated load (refer to ARP1247).

3.4.8 Drive wheels shall have at least a 2.0-inch (5-cm) clearance under rated load to permit the installation of tire chains.

3.4.9 Manufacturer shall specify recommended and maximum allowable battery weight (full rated load).

3.4.10 Beginning at full charge, vehicles should be capable of operating and charging after being out of service in an ambient temperature between 40 and 120 °F and off charge for 16 days. No operator action should be required during this period.

3.4.11 The physical layout of the tractor should be the best compromise of design, performance, operator utility, safety, maintenance and servicing. The rear bumper plate shall have sufficient strength and support to withstand the maximum drawbar pull requirement (see 4.2). The front bumper plate shall have sufficient strength and support to withstand normal abuse encountered in the handling of baggage and cargo trailers in airline service.

3.4.12 Dimensions of the tractor should not exceed 56 inches (142 cm) in width, 108 inches (274 cm) in length or 74 inches (188 cm) height measured from the ground to the highest point not including cab. (See Section 7 for optional tractors with cabs or low profile designs.)

3.4.13 The minimum ground clearance shall be 6 inches (15 cm) as measured to the lowest point (sprung or unsprung) on the tractor under rated load conditions. An 8-inch (20-cm) minimum ground clearance should be provided.

3.4.14 Mechanical systems shall comply with the requirements of ARP1247.

3.5 The tractor should comply with the requirements of NFPA 505 and UL 583 for Type E, ES, EE, or EX vehicles. Manufacturer shall specify whether the tractor meets the requirements of Type E, ES, EE, or EX.

4. PERFORMANCE REQUIREMENTS

4.1 The following performance requirements apply to dry level concrete (co-efficient of friction of 0.7 or better), with an outdoor ambient and traction battery temperature of 77 °F (25 °C), unless otherwise specified.

4.2 The manufacturer shall design the tractor to produce the maximum static drawbar pull at a 12-inch (30-cm) hitch height, with the traction battery at 50% (±10%) state of charge.

4.3 The maximum tractor speed with no towed load shall be greater than 12 mph and the maximum tractor speed shall be settable by a controlled method.

4.4 The manufacturer shall design the tractor to produce the maximum draw bar of the tractor at a 12-inch (30-cm) hitch height, at a speed of at least 6.2 mph (10.0 km/h) with the traction battery at 50% (±10%) state of charge.

4.5 At the maximum drawbar stated in 4.4, the controller, motor and battery shall be capable of continuous operation at 6.2 mph (10.0 km/h) for 15 minutes without overheating or damage to the propulsion system.

4.6 The tractor shall maneuver at full speed without under steer or over steer. Steering effort shall not be excessive. The manufacturer shall report the turning radius as measured from the furthest protrusion at the front of the tractor. While maneuvering at minimum turning radius, the tractor shall not produce excessive tire scrubbing.

5. BRAKING

5.1 Braking shall require a brake pedal force of not more than 100 pounds (445 N).

5.2 The manufacturer shall report the service brakes stopping distance from 12 mph without load.

5.3 The manufacturer shall report the service brakes stopping distance of the tractor from 6.2 mph (10 km/h) with a towed load of 25000 pounds (11340 kg) on level ground with no swerving of the tractor or jack-knifing of the load.

5.4 The tractor and towed load of 25000 pounds (11340 kg) shall be held on an incline of at least 10% (5.8°) by either the service brake or the hand brake.

5.5 Regenerative braking shall not adversely impact the tractor's braking stability, particularly on varying road surfaces.

5.6 In its most unstable condition, the tractor shall be stable in operation at inclines up to 17.5% (10°) fore and aft and 8.7% (5°) sideways (refer to ARP1247).

5.7 The tractor shall conform to the reliability requirements of ARP1247.

5.8 Tractors shall be capable of driving through 2 inches of standing water at 12 mph without damage, without becoming inoperable.

6. OPERATOR CONSIDERATIONS

6.1 Instruments and Controls

6.1.1 Instruments and controls shall comply with the requirements of ARP1247.

6.1.2 Instrumentation shall include, as a minimum, a battery state of charge indicator and an hour meter. An indicator light for the brake system as per 3.4.3 is required on the dash.

6.1.3 The vehicle should include a state of charge indicator for the propulsion battery. Indications should be repeatable and accurate to ±10% of full scale.

6.2 Entry and exit to the operator's seat shall require minimum effort and be without obstructions.

6.3 The tractor shall be designed with operator visibility as a primary consideration.

6.4 Dimension requirements for the tractor operating area as defined in Figure 1 should be followed. Dimensions are included for tractors with optional cabs (see Section 8).

6.5 The tractor should be equipped with a full seat including backrest with dimensions shown in Figure 1. The seat or supporting structure shall not transmit excessive vibration or shock to the operator. The seat shall be fitted with a hip restraint located on the outside of the vehicle and a seat belt.

6.6 The tractor suspension system shall not transmit excessive shock or vibration to the operator

6.7 Safety Requirements

6.7.1 Safety requirements shall comply with ARP1247, AIR1375, and ANSI B56.9. For operations at airports in EU or E.F.T.A. countries, the tractor shall, in addition, comply with the requirements of European Standards EN 1915-1 and EN 12312-15.

6.7.2 The tractor shall be equipped with a rearview mirror, properly mounted to prevent accidental mis-adjustment or visual distortion. If equipped with cab, the mirror shall be mounted inside same.

6.7.3 Brake pedals and all work surfaces shall be equipped with non-slip material and/or painted with durable non-skid paint.

6.7.4 Lamps, accessories, and other surface mounted equipment should be protected by guards to minimize the likelihood of damage.

6.7.5 All components and systems shall be fail-safe.

6.7.5.1 A dead man type seat switch shall be supplied with an interlock that de-activates the traction circuit whenever the operator is not on the seat. The switch and its installation shall be designed to prevent false tripping due to driving over bumps or the operator leaning in any direction on the seat. As an alternative, a dead man type pedal depressed by the operator's foot may be used.

6.7.5.2 The controller shall incorporate a "static return to off" feature. This is another interlock that requires the operator to set the directional control to neutral before tractor movement is possible once the seat switch has been opened.

6.7.5.3 A handbrake interlock shall also be provided to prevent traction system operation unless the handbrake is disengaged.

6.7.5.4 Vehicles using HIGH VOLTAGE (>60 V) traction systems shall be equipped with a battery disconnect device to render the propulsion system inoperative

A manual service disconnect for vehicles using a HIGH VOLTAGE traction system shall also be required. It shall have the following characteristics:

- Manual action is required to break the connection,
- The disconnection is physically verifiable,
- The disconnection does not create exposed conductors capable of becoming energized while exposed, and
- The service disconnect is clearly marked and is accessible without the use of tools.

6.7.6 The tractor shall be designed for easy access to those areas that require frequent checks and/or servicing.

6.7.7 Proper placarding of permanent design shall be used for all controls, instrumentation and cautionary information.

6.7.8 Information regarding maximum towing speed shall be properly placarded on the dash and at the tow points if potential damage exists to the traction motor during maintenance towing at higher than recommended speeds.

6.7.9 Tire inflation pressures shall be placarded or stenciled above the wheel well on the tractors.

6.7.10 Jack points shall be placarded on the tractor at all locations.

## 7. MAINTENANCE REQUIREMENTS

7.1 Service access shall comply with the requirements of ARP1247.

7.2 Every effort should be made to facilitate maintenance access according to required check frequency or probability of failure of each system or component. In particular, the electrical compartments shall be located and laid out such that checks and troubleshooting can be accomplished easily and rapidly.

7.3 Systems and components requiring expertise not normally found with ground equipment mechanics shall have adequate troubleshooting charts and procedures. Simplified and/or automatic test equipment is encouraged.

7.4 The tractor shall be supplied with a manual, which complies with the requirements of AS4828.

7.4.1 The manual shall include a complete electrical schematic, wiring diagram and component location chart.

7.4.2 Jacking instructions and pad locations shall be adequately illustrated in the manual.

7.5 Any special tools or test equipment shall be identified in the manual and drawings or source of procurement documented.

8. OPTIONS

Options as listed below shall be the minimum offered to accommodate different operational procedures.

8.1 Where a passenger seat is provided, it shall be offered with a hip restraint located to the outside of the vehicle and a seat belt.

8.2 A tractor with a fully enclosed cab shall be offered. Consideration should be given to the general appearance of the tractor with a cab in this design. The specifications given in ARP1247 shall apply.

8.2.1 The overall height of the cab shall not be more than 78 inches (198.1 cm) for the standard tractor.

8.2.2 The interior dimensions defining operator room, controls and their relative location shall be as good as or better than those shown in Figure 1. Special emphasis on visibility is required with this option. Corner posts shall be made as small as possible within structural requirements to increase front and side vision.

8.2.3 The cab shall be equipped with two removable doors or with vinyl doors with zippers.

8.2.4 Optional cab accessories shall include a window heater/defroster, dome light, hazard light, turn signals, and provisions for a ramp two-way radio. It is recommended that these accessories be powered by the 12 or 24 V accessory circuit, except that the heater/defroster coils be powered by battery voltage.

8.2.5 A low profile tractor for side loading of containerized cargo shall be offered with all the options in this paragraph.

8.2.5.1 The maximum overall height of the cab in this case shall be 66 inches (167.6 cm), including optional hazard lights.

8.2.5.2 A fixed window in the cab roof over the driver's seat for upward visibility shall be offered.

8.3 An indicator light on the dash to caution the operator of motor brush wear should be offered where applicable.

8.4 A guarded, recessed inching switch at the rear of the tractor with adequate safety interlocks should be offered.

8.5 A means of securing the main power battery on the tractor in the event of accidental overturning should be offered.

8.6 Turn signals on the rear of the tractor should be offered.

8.7 Cold weather option for battery should be offered.

8.8 Hazard flashers complying with the requirements of 3.3.3.3.

8.9 Hazard lights, if provided, should be capable of at least 1 hour of continuous operation in the event of shutdown or isolation of the propulsion battery pack or failure of the DC/DC converter system as required by SAE J1690.

8.10 When utilizing the universal charging method (e.g., charger that communicates with the vehicle battery pack and capable of automatically charging a wide range of battery packs, typically in half or less the time to charge with conventional chargers), the vehicle charge receptacle shall be compatible with ARP1892 Revision C. The vehicle shall incorporate a method to ensure the receptacle high-voltage pins are not energized when exposed to human contact and during normal vehicle operation, and the vehicle shall be immobilized to prevent a “drive-off” scenario when the charge plug is engaged in the vehicle receptacle. The charge receptacle shall be located on the vehicle in such a way as to minimize incidental connector snags after the operator removes the charge connector from the vehicle charge receptacle.

8.11 An electrically operated parking brake may be supplied. Such brakes should have a manual release for towing in the event of power failure.

8.12 The battery module should comply with the requirements of “CiA Standard 418.”

8.13 The vehicle-charger communication protocol should meet the requirements of “CiA Standard 419.”

9. NOTES

9.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.